

This Page Is Inserted by IFW Operations  
and is not a part of the Official Record

## **BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning documents *will not* correct images,  
please do not report the images to the  
Image Problems Mailbox.**



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification <sup>6</sup> : <b>G01H 10/06, G01P 15/08, G10K 11/178</b></p>	<p><b>A1</b></p>	<p>(11) International Publication Number: <b>WO 98/22785</b></p> <p>(43) International Publication Date: 28 May 1998 (28.05.98)</p>
<p>(21) International Application Number: PCT/FI97/00706</p> <p>(22) International Filing Date: 19 November 1997 (19.11.97)</p> <p>(30) Priority Data: 964637 20 November 1996 (20.11.96) FI</p> <p>(71) Applicant (for all designated States except US): VTT [FI/FI]; Vuorimiehentie 5, FIN-02150 Espoo (FI).</p> <p>(72) Inventors; and (75) Inventors/Applicants (for US only): KIRJAVAINEN, Kari [FI/FI]; Kivenlahdenkatu 11 A, FIN-02320 Espoo (FI). LEKKALA, Jukka [FI/FI]; Liinaharjankatu 10, FIN-33730 Tampere (FI). NYKÄNEN, Hannu [FI/FI]; Timpurinkatu 3, FIN-33720 Tampere (FI). UOSUKAINEN, Seppo [FI/FI]; Lehmustie 1 B, FIN-00780 Helsinki (FI).</p> <p>(74) Agent: KOLSTER OY AB; Iso Roobertinkatu 23, P.O. Box 148, FIN-00121 Helsinki (FI).</p>		<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</p>
<p>(54) Title: SENSOR FOR MEASURING ACCELERATION AND SOUND PRESSURE</p>		
<p>(57) Abstract</p> <p>The invention relates to a sensor for measuring acceleration and sound pressure, the sensor comprising means for measuring pressure (P) and means for measuring acceleration. The means for measuring pressure (P) and acceleration are arranged concentrically in the same plane, the pressure (P) and acceleration being measured at exactly the same point, and e.g. a phase shift not being able to cause error in the measurement result.</p>		

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

## SENSOR FOR MEASURING ACCELERATION AND SOUND PRESSURE

The invention relates to a sensor for measuring acceleration and sound pressure, the sensor separately comprising means for measuring the acceleration of a surface and means for measuring the sound pressure affecting the surface.

Extremely accurate values of the magnitudes of the acceleration and the pressure affecting a surface are needed e.g. in an application which actively attenuates sound and oscillation caused by noise. Said values are needed for controlling the means, i.e. actuators, generating counter-oscillation.

Since the signals to be measured are wave-formed, completely reliable measurement results are extremely difficult to obtain, since a phase difference can be present at the time of measurement in two different measurements, the phase difference excessively interfering with the final result.

German Publication No. 4,342,169 discloses an electromechanical transformer operating as e.g. a microphone. Said transformer comprises a film for emitting a signal which is proportional to the sound pressure and/or surface acceleration. However, the transformer cannot be used in accurate sound attenuation applications since the sound pressure and acceleration signals cannot be distinguished one from the other.

It is the object of the present invention to provide a sensor for measuring acceleration and sound pressure accurately and reliably.

The sensor of the invention is characterized in that the means for measuring the acceleration and the means for measuring the sound pressure are arranged substantially concentrically and substantially in the same plane.

An essential idea of the invention is that the means for measuring acceleration and the means for measuring sound pressure are arranged concentrically in the same plane. The idea of a preferred embodiment is that the means for measuring pressure is circular and the means for measuring acceleration is arranged in the middle of said circle. The pressure sensor is most preferably formed of pressure-sensitive film having flat gas bubbles and a metal coating on at least one side, a permanent electric charge being formed in the film, the sensor emitting an electric signal proportional to the pressure. Furthermore, the acceleration sensor is preferably made of similar material by adding a mass on top of it and arranging the acceleration sensor in such a way that pressure changes do not affect it, but the movement of the surface to be measured causes the mass disposed upon the material to emit a signal.

It is an advantage of the invention that one of the measuring means, arranged concentrically in the same plane, measures pressure and the other measures acceleration from the same place at the same time, whereby no error caused by a phase error can affect the measurement result, i.e. the measurement is reliable and accurate. When the same material is mainly used in the acceleration and pressure measurement sensors, the sensor production technique becomes easy. By arranging the acceleration sensor such that a mass is placed on the pressure-sensitive film, the resulting acceleration sensor is not substantially affected by lateral movements.

10 The invention will be described in more detail in the attached drawings, in which

Figure 1 is a schematic sectional side view the sensor of the invention, and

Figure 2 is a top view of the sensor of Figure 1.

15 Figure 1 shows a sensor 1 for measuring acceleration and sound pressure. The means for measuring the sound pressure is a pressure-sensitive film 2. The film 2 comprises flat gas bubbles and has a metal coating on at least one side, and a permanent electric charge, i.e. what is known as an electret charge, is formed in it. As pressure P affects said film, the film emits an electric signal proportional to the pressure, i.e. it is a capacitive sensor. The mass of the film 2 is so small that its movement does not substantially generate a signal, essentially all signals being generated by a change in the pressure P affecting the film 2. The film 2 is encased in a housing 3 provided with holes 4 through which pressure changes, i.e. in practice, changes in sound pressure, affect the film 2.

25 The film 2 is circular and the means for measuring acceleration are arranged in its midpoint. The means for measuring acceleration comprise a pressure-sensitive film 5 and a mass 6 disposed on top of the film. The film 5 is of similar material as the film 2. The film 5 and the mass 6 are encased in a protective casing 7 for preventing a change in sound pressure from affecting the film 5. Consequently, substantially only the weight of the mass 6 affects the film 5, whereby with the surface of a body 8, moving in the direction shown by arrow A, the weight of the mass 6 affects the film 5, whereby the acceleration of the surface of the body 8 in the directions of arrow A can be measured.

30 The protective casing 7 may comprise very small holes or pores through which the air pressure inside the protective casing 7 is allowed to even out, the holes

35

or pores being so small that the sound pressure  $P$  cannot affect the film. The acceleration sensor of Figure 1 is not substantially affected by lateral acceleration. The acceleration sensor and the sound pressure sensor are separate, allowing the sound pressure and surface acceleration to be measured separately. Furthermore, the acceleration sensor and the sound pressure sensor are substantially in the same plane.

The films 2 and 5 and the housing 3 and the protective casing 7 are secured to a base plate 9. Microcircuits for amplifying signals, for example, can be arranged in the base plate 9. The measured signals are led via a connecting wire 10 to be further utilized. The base plate 9 may also be of silicon substrate, whereby a circuit comprising the electronics necessary for signal processing can be integrated therein. The electronics of the sensor 1 can also be adapted to form the mass 6.

The sensor can be dimensioned very small, e.g. with a diameter of about 10 mm or even less and a thickness of e.g. about 1 mm or even less. Since the film 5 is very light and sensitive, the mass 6 does not have to be heavy, but a mass of e.g. 0.1 g or less is adequate.

Figure 2 is a top view of the sensor of Figure 1. The numbering of Figure 2 corresponds to that of Figure 1. For the sake of clarity, the housing 3, the protective casing 7, and the mass 6 are not shown in Figure 2. As can be seen from Figure 2, the film 2 is annular and the film 5 is arranged substantially in its middle.

Acoustic surface intensity measurements are important applications of the sensor 1. A velocity signal is achieved from the measured acceleration signal by integration in a manner fully known per se. Said integration can be included in the electronics part of the sensor 1, if desired.

The drawing and the related description are only intended to illustrate the inventive idea. As to its details, the invention may vary within the scope of the claims. Consequently, the means for measuring acceleration and pressure may be any kind of means known per se, as long as they are arranged concentrically in the same plane. The sensor may also be constructed by arranging the means for measuring pressure in the middle and the means for measuring acceleration e.g. in the shape of a ring around them. However, the preferable way to carry out the measurements has been described above.

The sensor can be micromechanically made on silicon. The sensor 1 can, of course, be used e.g. only as a microphone or a mere acceleration sensor.

## CLAIMS

1. A sensor for measuring acceleration and sound pressure, the sensor (1) separately comprising means for measuring the acceleration of a surface and means for measuring the sound pressure (P) affecting the surface, **characterized** in that the means for measuring the acceleration and the means for measuring the sound pressure (P) are arranged substantially concentrically and substantially in the same plane.

2. A sensor as claimed in claim 1, **characterized** in that the means for measuring pressure is annular and the means for measuring acceleration is disposed substantially in its middle.

3. A sensor as claimed in claim 1 or 2, **characterized** in that the means for measuring pressure comprises a pressure-sensitive film (2) having flat gas bubbles and a metal coating on at least one side, and in which a permanent electric charge has been formed.

4. A sensor as claimed in any one of the preceding claims, **characterized** in that the means for measuring acceleration comprises a pressure-sensitive film (5) having flat gas bubbles and a metal coating on at least one side, and in which a permanent electric charge has been formed, a mass (6), arranged on top of the film (5), and a protective casing (7) arranged around the film (5) and the mass (6) in order for sound pressure (P) not to be able to substantially affect the film (5).

5. A sensor as claimed in any one of the preceding claims, **characterized** in that the sensor (1) comprises the electronics needed for signal processing.

6. A sensor as claimed in claim 5, **characterized** in that the sensor (1) comprises a base plate (9) into which a circuit containing the electronics needed for signal processing is integrated.

1/1

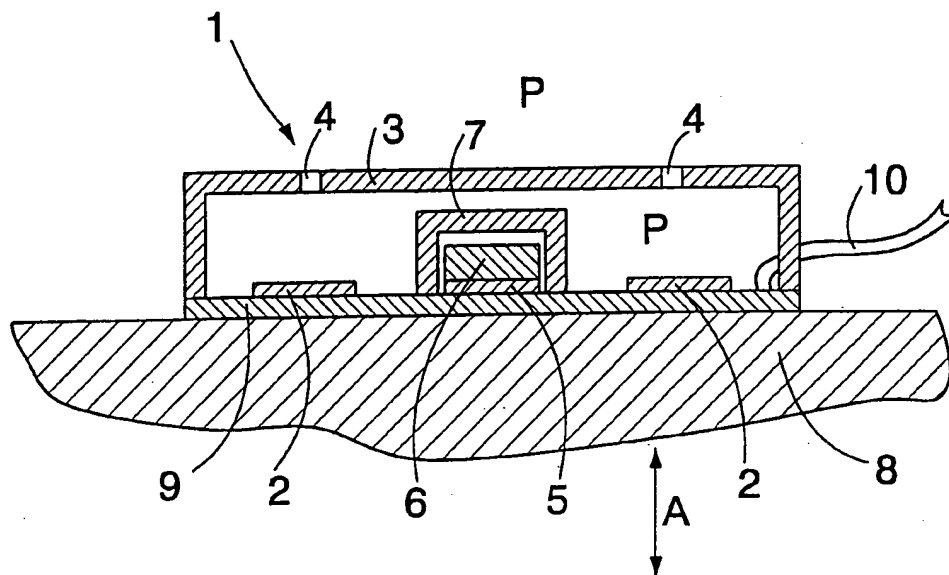


FIG. 1

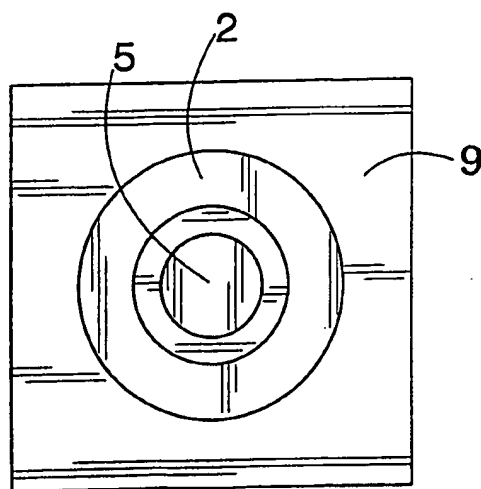


FIG. 2



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 97/00706

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>		
<b>IPC6: G01H 10/06, G01P 15/08, G10K 11/178</b> According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols)		
<b>IPC6: G01H, G01P, G10K</b>		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
<b>SE,DK,FI,NO classes as above</b>		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4654546 A (K. KIRJAVAINEN), 31 March 1987 (31.03.87), column 4, line 33 - line 65, figure 5A --	1-6
A	SU 1808024 A3 (V.V. KOLOSOV), 7 April 1993 (07.04.93), figure 1, abstract --	1-6
A	DE 4410794 A1 (ADS MESSTECHNIK GMBH), 5 October 1995 (05.10.95), figures 1,2, abstract --	1-6
A	Patent Abstracts of Japan, Vol 96, No 7 abstract of JP 8-184608 A (NIPPONDENSO CO LTD), 16 July 1996 (16.07.96) --	1-6
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
27 March 1998		30 -03- 1998
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86		Authorized officer Lars Jakobsson Telephone No. +46 8 782 25 00

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 97/00706

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 4342169 A1 (SENNHEISER ELECTRONIC KG), 14 June 1995 (14.06.95), figures 1-9, abstract --	1-6
A	GB 2235533 A (STC PLC), 6 March 1991 (06.03.91), figures 1,2, abstract --	1-6
A	US 5519637 A (G. MATHUR), 21 May 1996 (21.05.96), figures 3,4, abstract --	1-6
A	US 5434371 A (L.E. BROOKS), 18 July 1995 (18.07.95), figures 1-5, abstract --	1-6
A	US 5325437 A (K. DOI ET AL.), 28 June 1994 (28.06.94), figures 1-4, abstract -- -----	1-6

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

02/03/98

International application No.  
PCT/FI 97/00706

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4654546 A	31/03/87	DK 533685 A EP 0182764 A,B SE 0182764 T3 JP 1832721 C JP 61148044 A	21/05/86 28/05/86  29/03/94 05/07/86
SU 1808024 A3	07/04/93	NONE	
DE 4410794 A1	05/10/95	NONE	
DE 4342169 A1	14/06/95	NONE	
GB 2235533 A	06/03/91	NONE	
US 5519637 A	21/05/96	NONE	
US 5434371 A	18/07/95	AU 1685695 A EP 0742933 A JP 9508729 T WO 9521433 A	21/08/95 20/11/96 02/09/97 10/08/95
US 5325437 A	28/06/94	DE 4244108 A JP 5181487 A	01/07/93 23/07/93